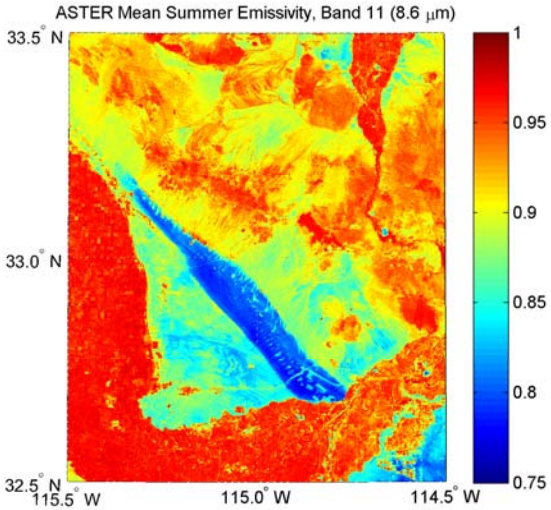
Jet Propulsion Laboratory
California Institute of Technology

The North American ASTER Land Surface Emissivity Database (NAALSED)



Glynn Hulley, Simon Hook

Jet Propulsion Laboratory, Caltech Institute of Technology, Pasadena, CA

Land Processes DAAC User Working Group (UWG) – October 13, 2008

Outline

- Motivation
- ASTER mean seasonal database
- ASTER cloud mask
- NAALSED Progess
- NAALSED Results
- Emissivity Validation
- Comparisons with AIRS and MODIS
- Future Work

Motivation

- One of most important Earth System Data Records (ESDR's) recently identified by NASA is Land Surface Temperature and Emissivity (LST&E)

- LST&E products are key to global climate change studies, climate modeling, surface-atmosphere interactions and land use, land cover change.

- Errors in emissivity of 0.1 (10%) results in climate models having errors of 6.6 Wm^2 in upward longwave radiation budgets (much larger term than effects of global warming due to increase in CO2).

- Errors in retrievals of temperature and moisture profiles from sensors such as Atmospheric Infrared Sounder (AIRS), strongly dependent on inaccurate emissivities, particularly over semi-arid regions.

- Knowledge of surface emissivity is critical in recovering the Land Surface Temperature, import for many scientific studies from climatology to hydrology to studying the greenhouse effect.

ASTER Mean, Seasonal Emissivity Product

- Underlying Assumption: No emissivity change UNLESS underlying surface changes
- Mean Summer (July-Aug-Sep) and Winter (Jan-Feb-Mar) emissivity (2000-2008)
- Data Used:
  - **AST_05 – Land Surface Emissivity**
  - **AST_08 – Land Surface Temperature**
- Developed ASTER Land Surface Emissivity Aggregation Algorithm (ALSEA)
- New ASTER Cloud Mask Algorithm (NACMA) to screen out cloudy pixels (MODIS/AVHHR/Landsat-7 spectral tests)
- Determine all intersecting scenes on 1°x1° given grid – 'stacking' method
- Output mean and standard deviation for all clear observations on each pixel
- 100 m spatial resolution
- Data products in hdf5 and binary format: Mean and SDev Emissivity (TIR bands), Temperature, NDVI, Land/Water map, Number of Observations, Geodetic Latitude, Longitude

** **Hulley et al.,** 2008, The ASTER Land Surface Emissivity Database of California and Nevada, *Geophys. Res. Lett.*, L13401, doi:10.1029/2008GL034507

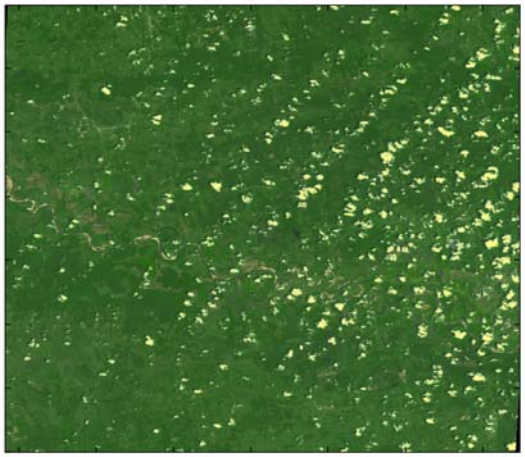
New ASTER Cloud Mask Algorithm (NACMA)

- Accurate cloud detection is critical for developing LSTE database
- Current ASTER L1A cloud mask lacks several key spectral tests for cloud detection, coarse resolution – 600 m
- Data Used:
  - **L1B – Registered radiance at sensor**
- Spectral tests set using TOA reflectance (Bands 1 – 5) and thermal brightness temperatures (Bands 13-14)
- New ASTER 'hybrid' cloud mask utilizes:
  - Landsat-7 two pass approach
  - MODIS shadow test
  - AVHHR thin cirrus test
- High resolution – 100 m
- Clear-sky conservative – overestimate clouds (filling technique)
- Cloud mask tested rigorously on dataset of 38 'difficult-scenario' scenes: cirrus over snow, highly reflective soils, snow, senescent vegetation

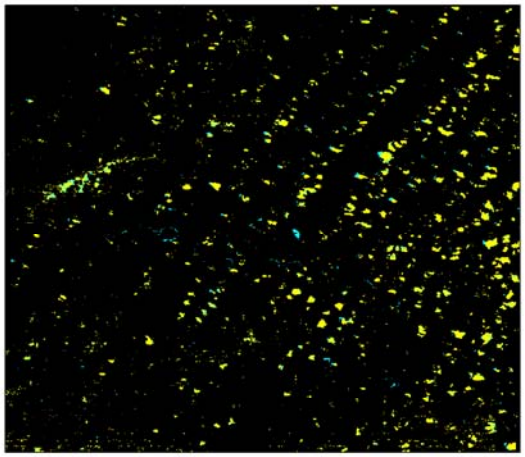
** **Hulley G.C., and S.J. Hook,** 2008, A New Methodology for Cloud Detection and Classification with Advanced Spaceborne Thermal Emission and Reflection (ASTER) Data , *Geophys. Res. Lett.*, in press.

NACMA Comparisons with MODIS and ASTER L1A Masks

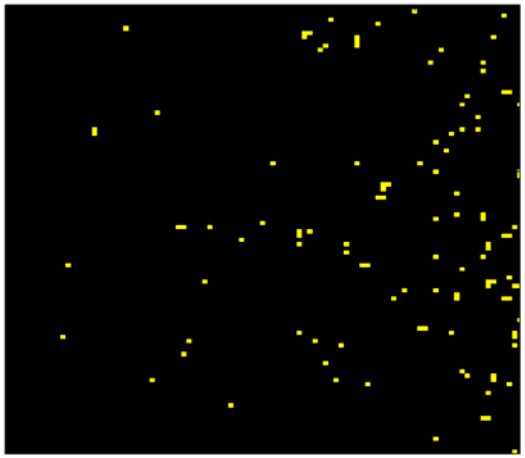
ASTER False-Color



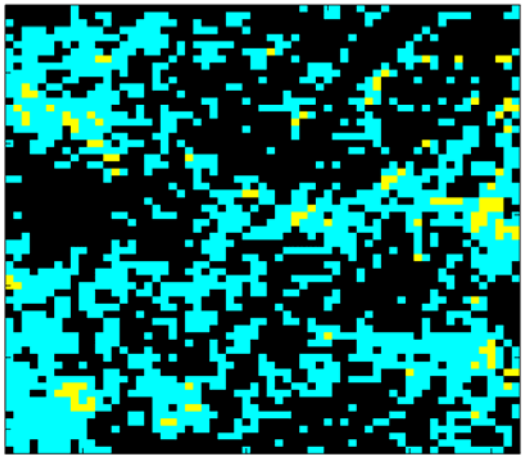
NACMA



ACCAA

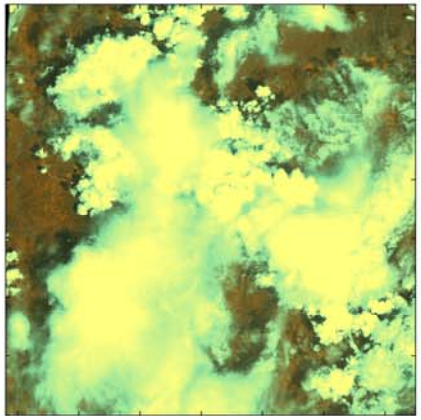


MODIS

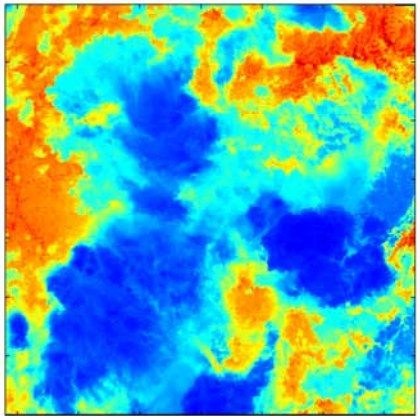


Multi-layer cloud detection

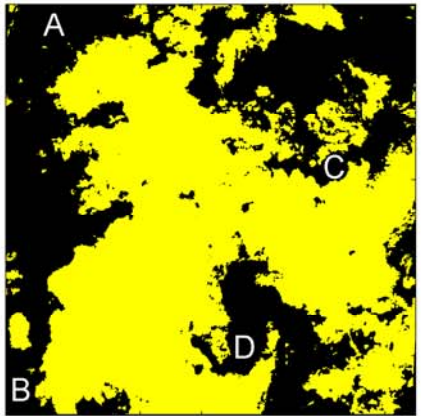
ASTER False-Color



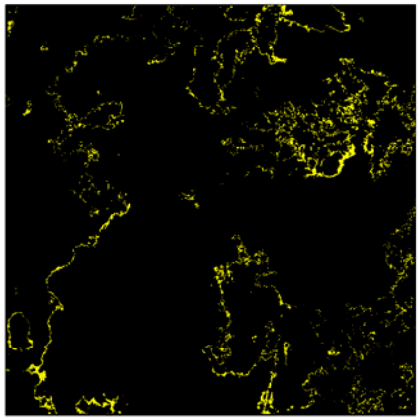
Brightness Temperature (10.6 μm)



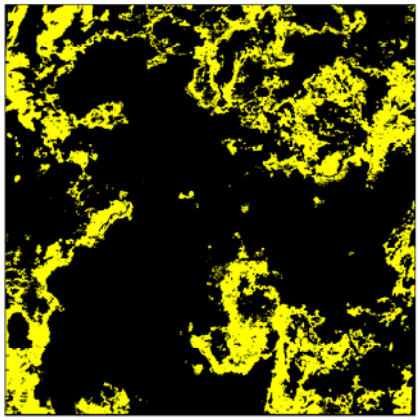
Pass 1 Clouds



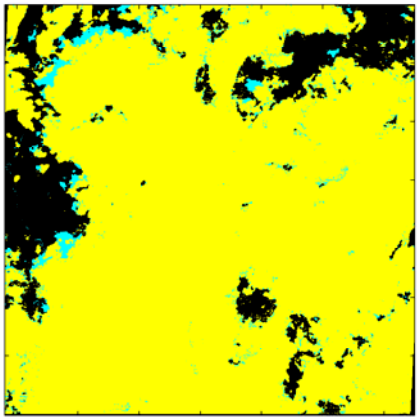
Pass 2 Clouds



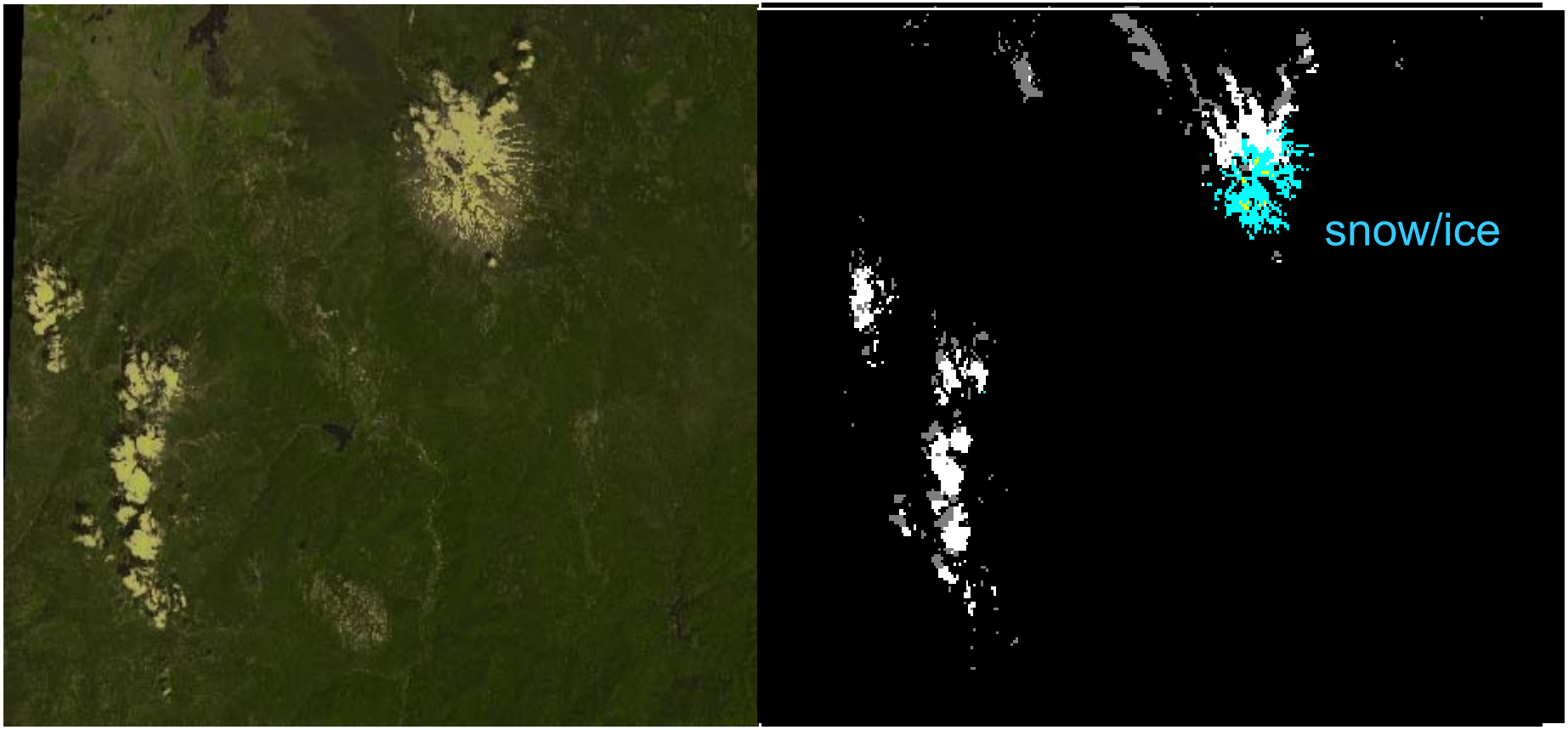
Thin Cloud/Cirrus test



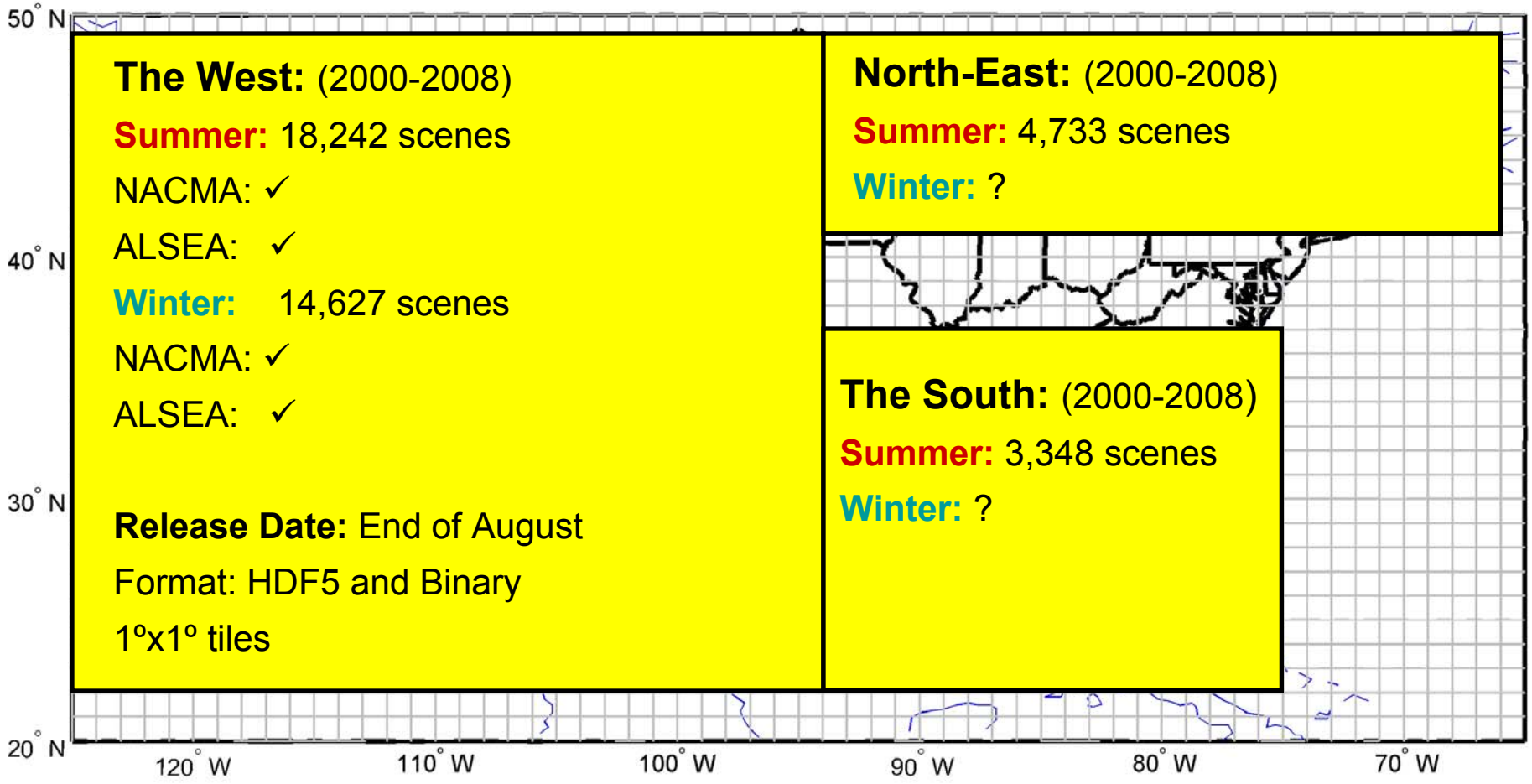
Final Cloud Mask



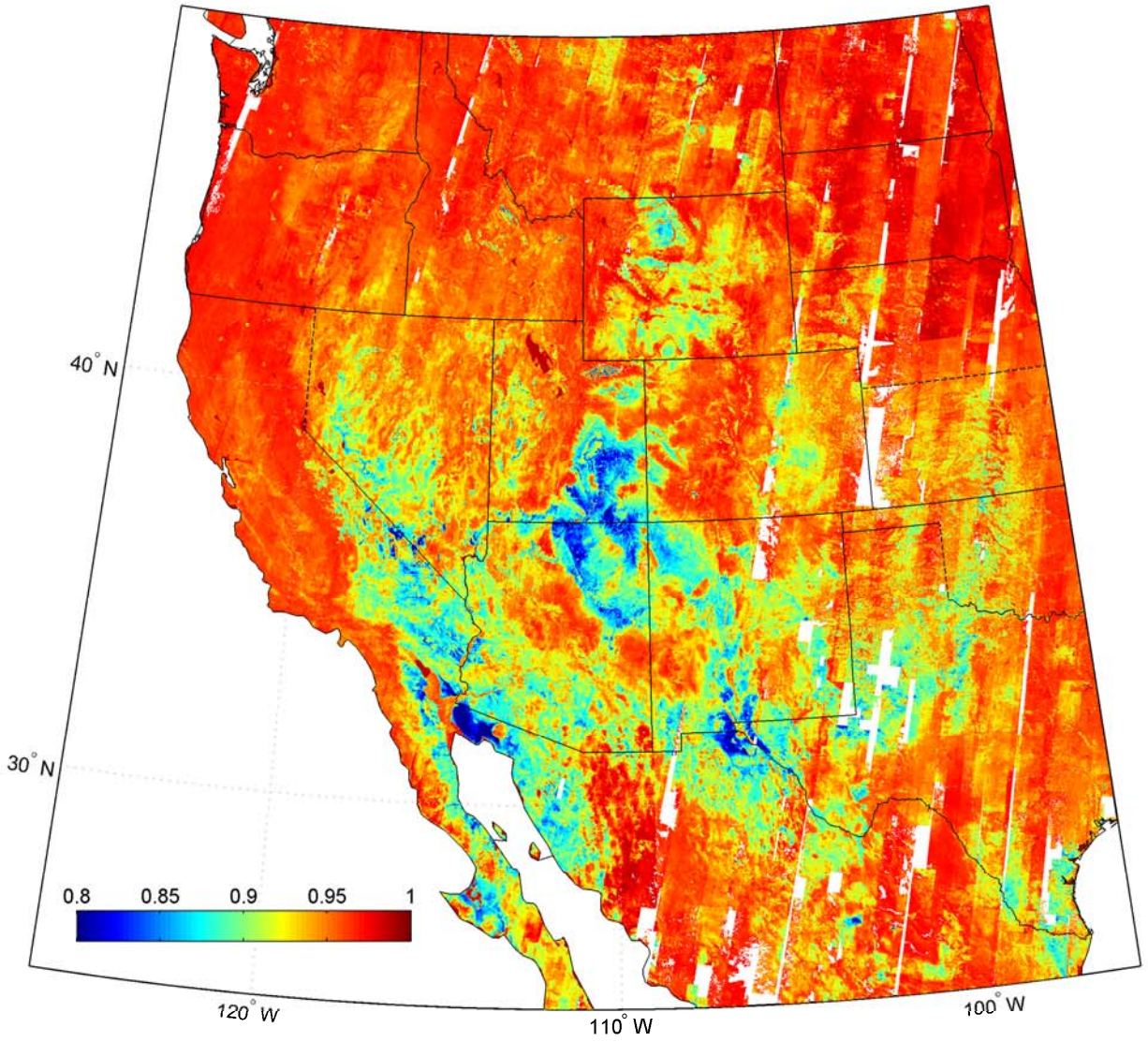
Cloud/Snow Discrimination



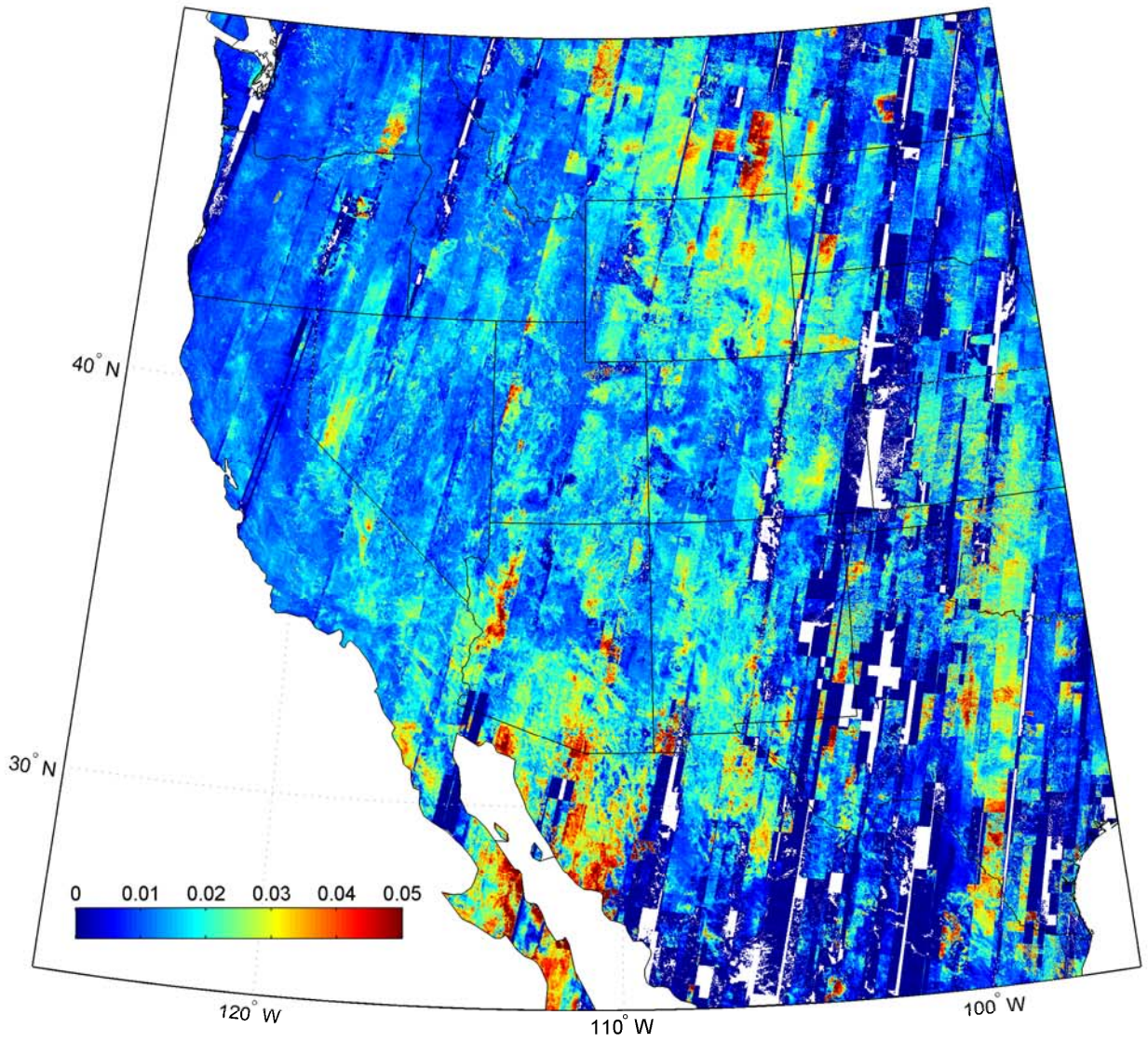
NAALSED Progress



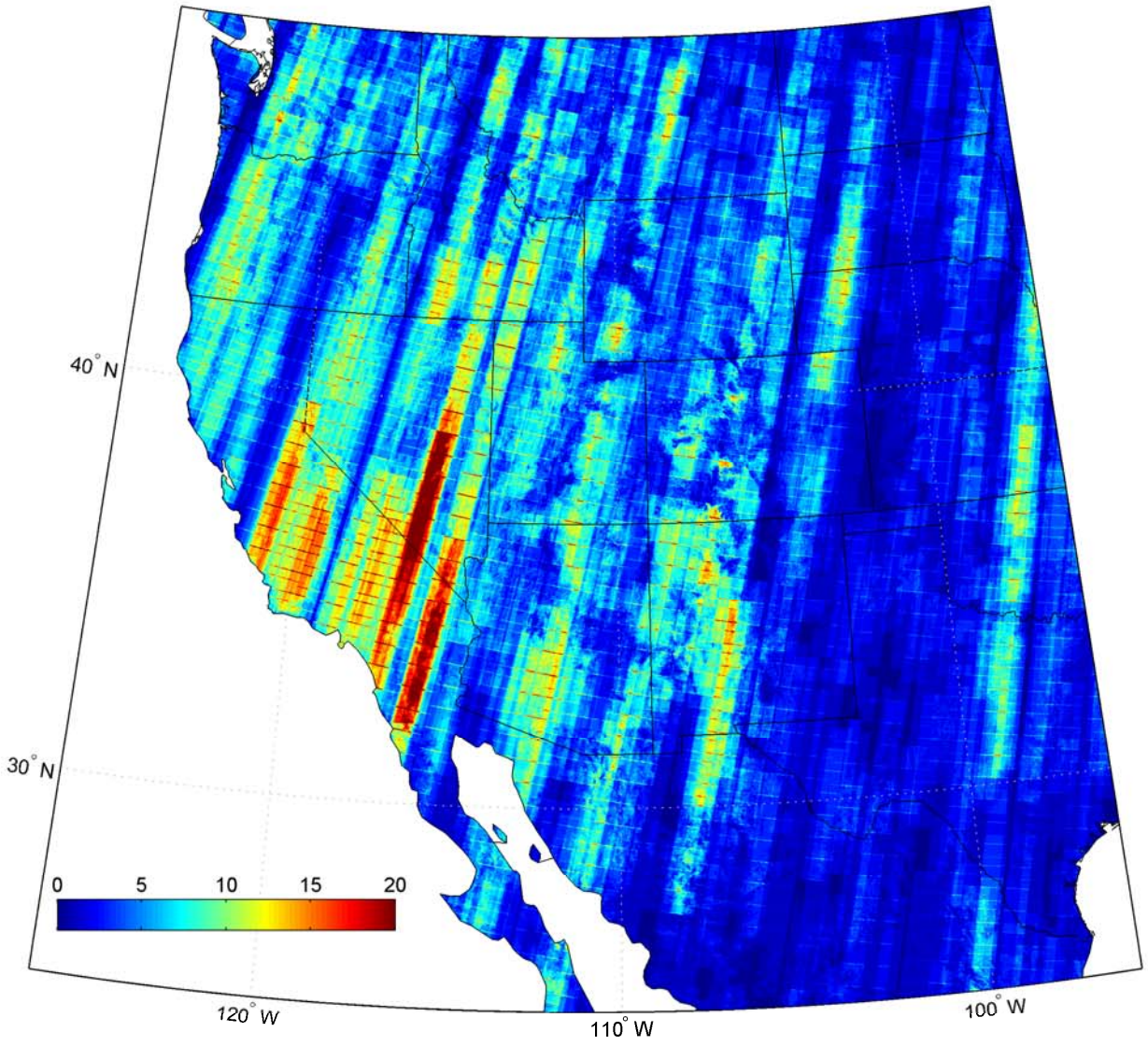
ASTER Mean Summer Emissivity, Band 12 (9.1 μm)



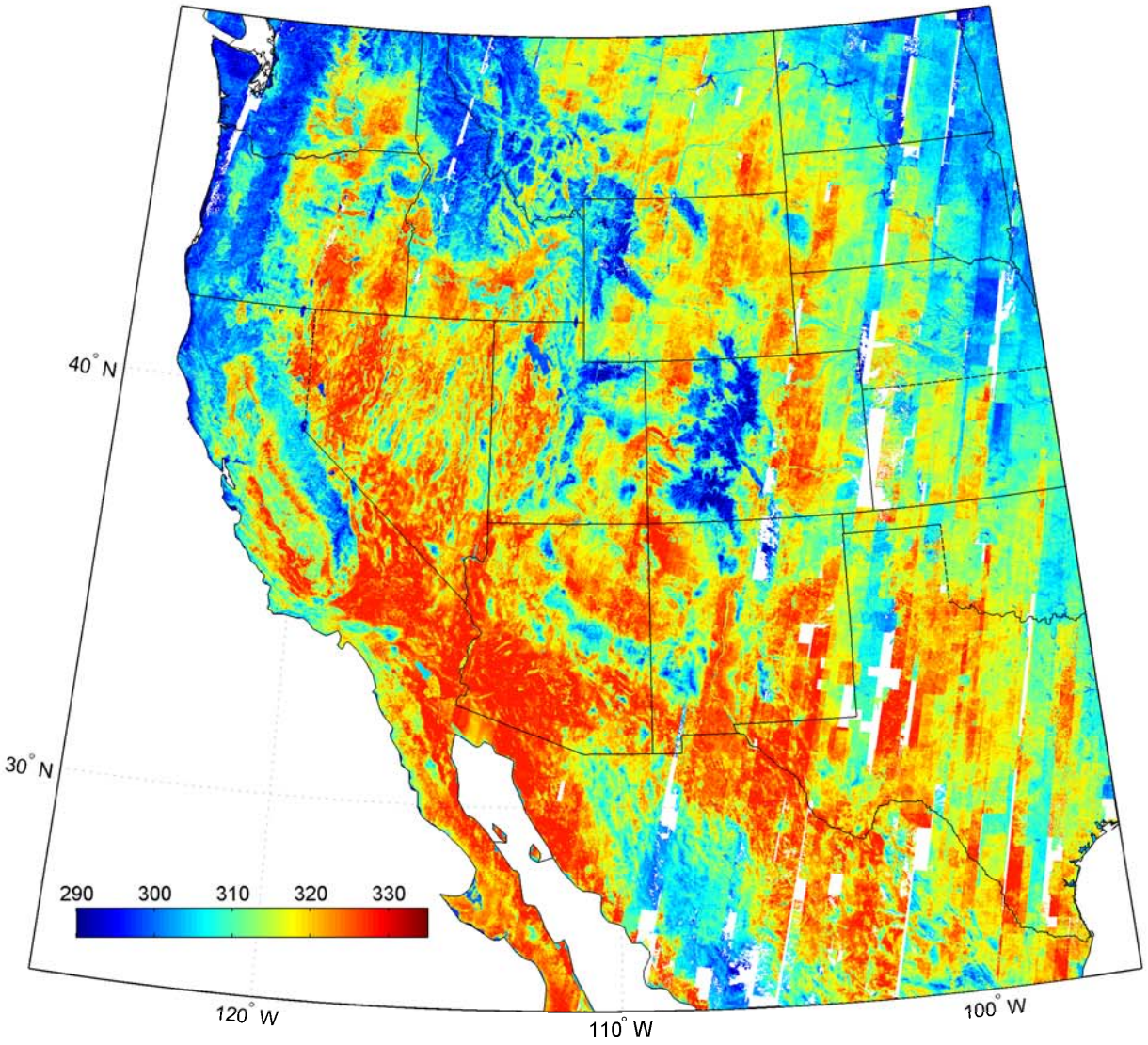
ASTER Summer Emissivity Standard Deviation, Band 12 (9.1 μm)



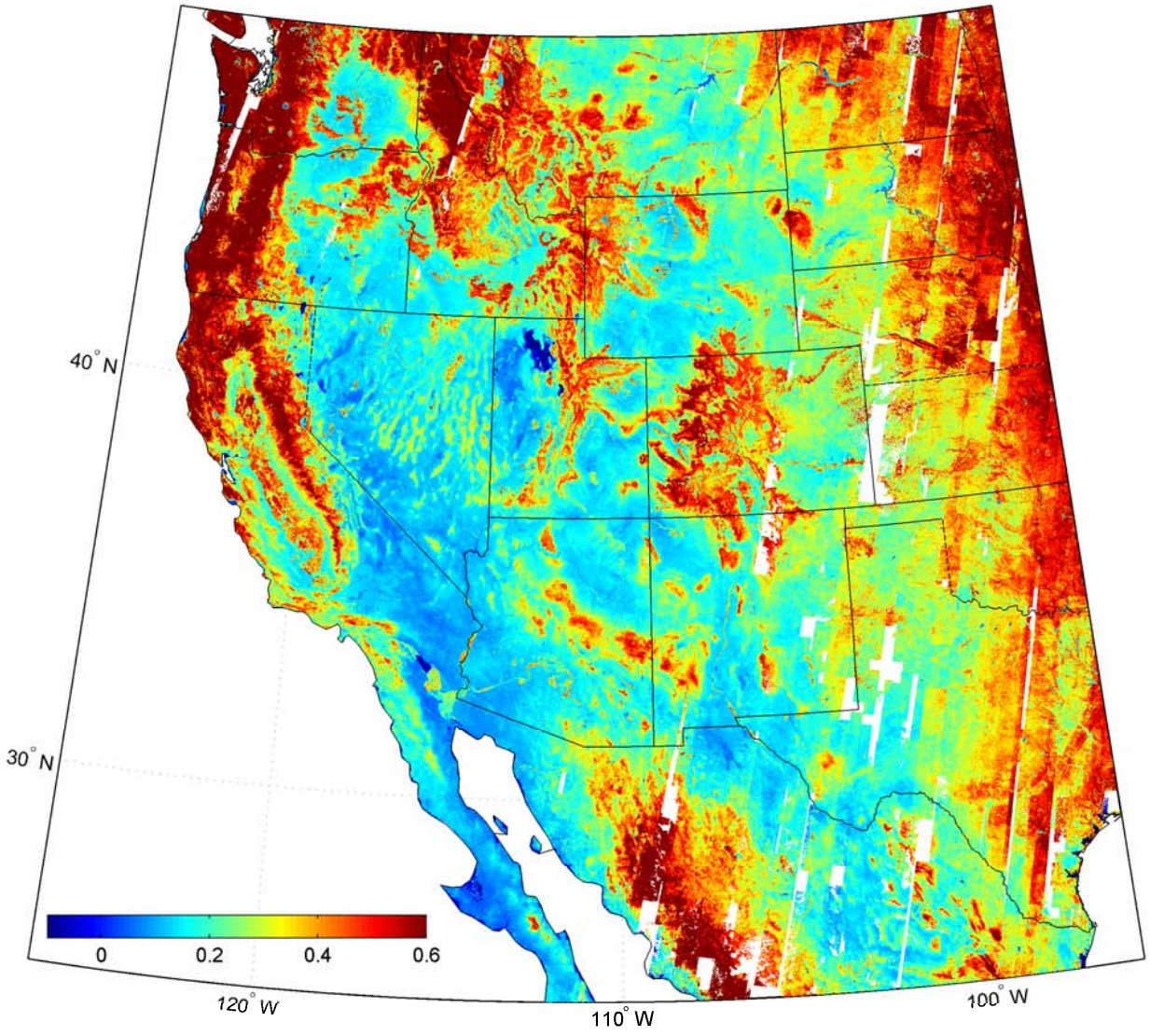
ASTER Total Summer Observations (2000-2008)

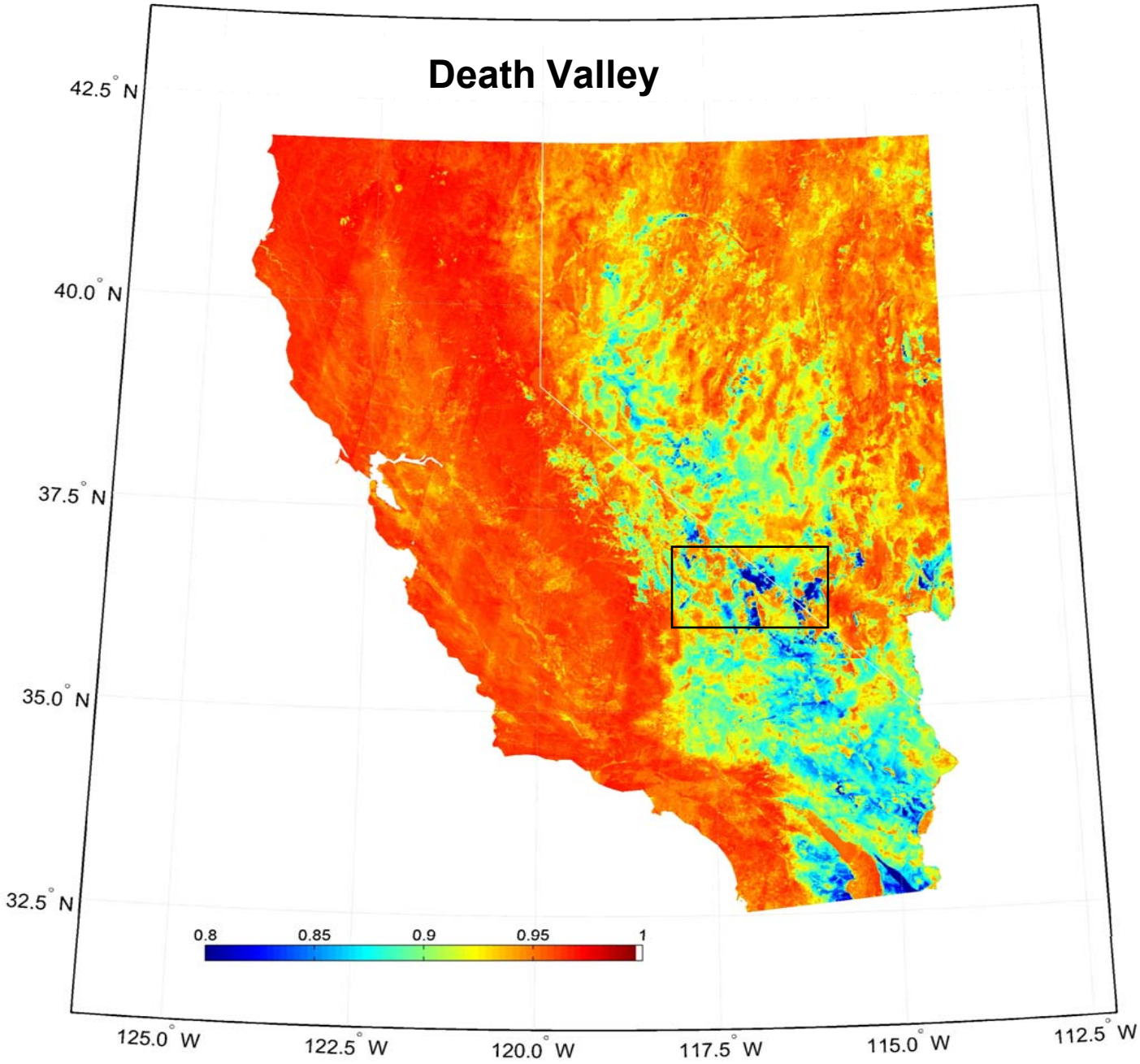


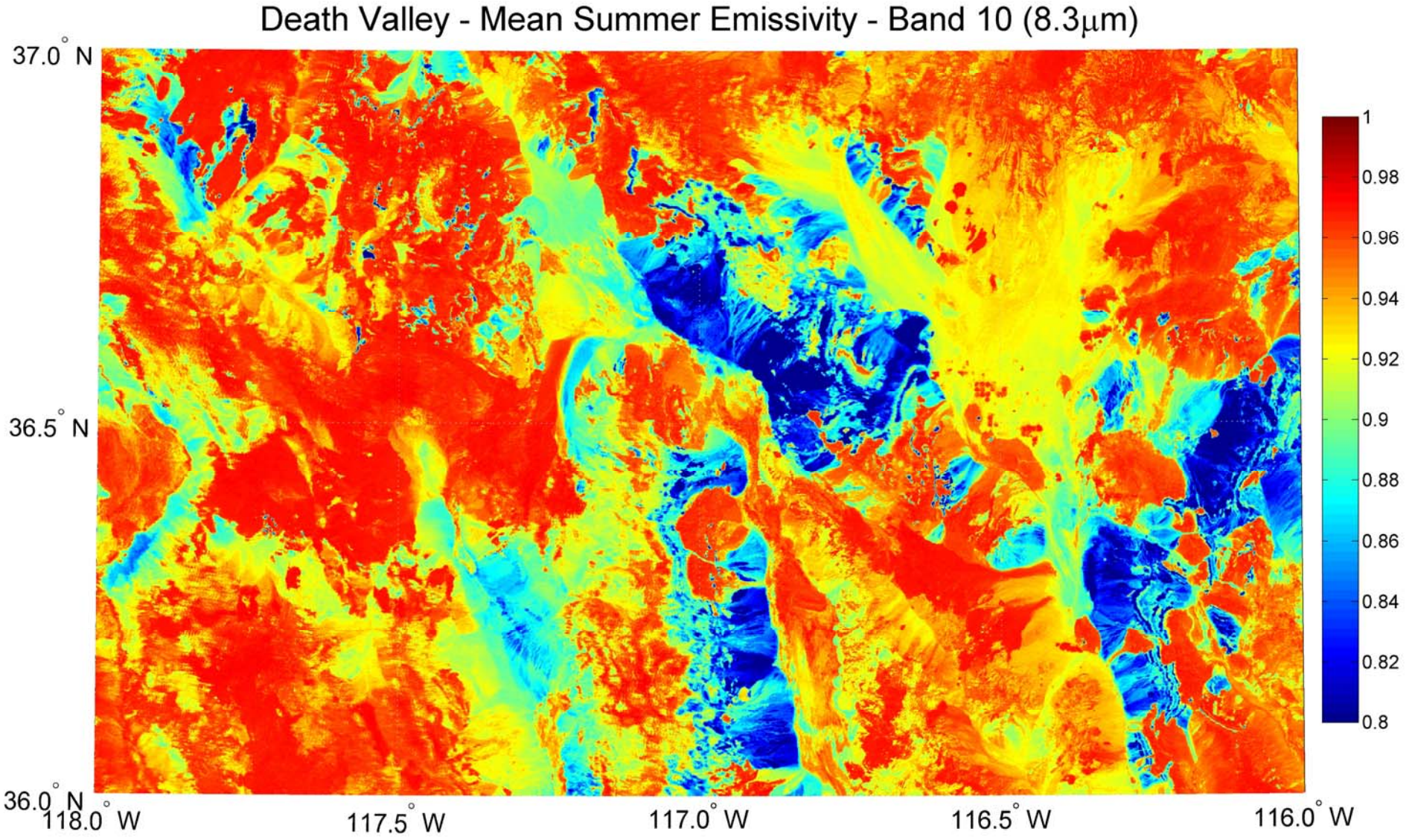
ASTER Mean Summer Temperature (Kelvin)

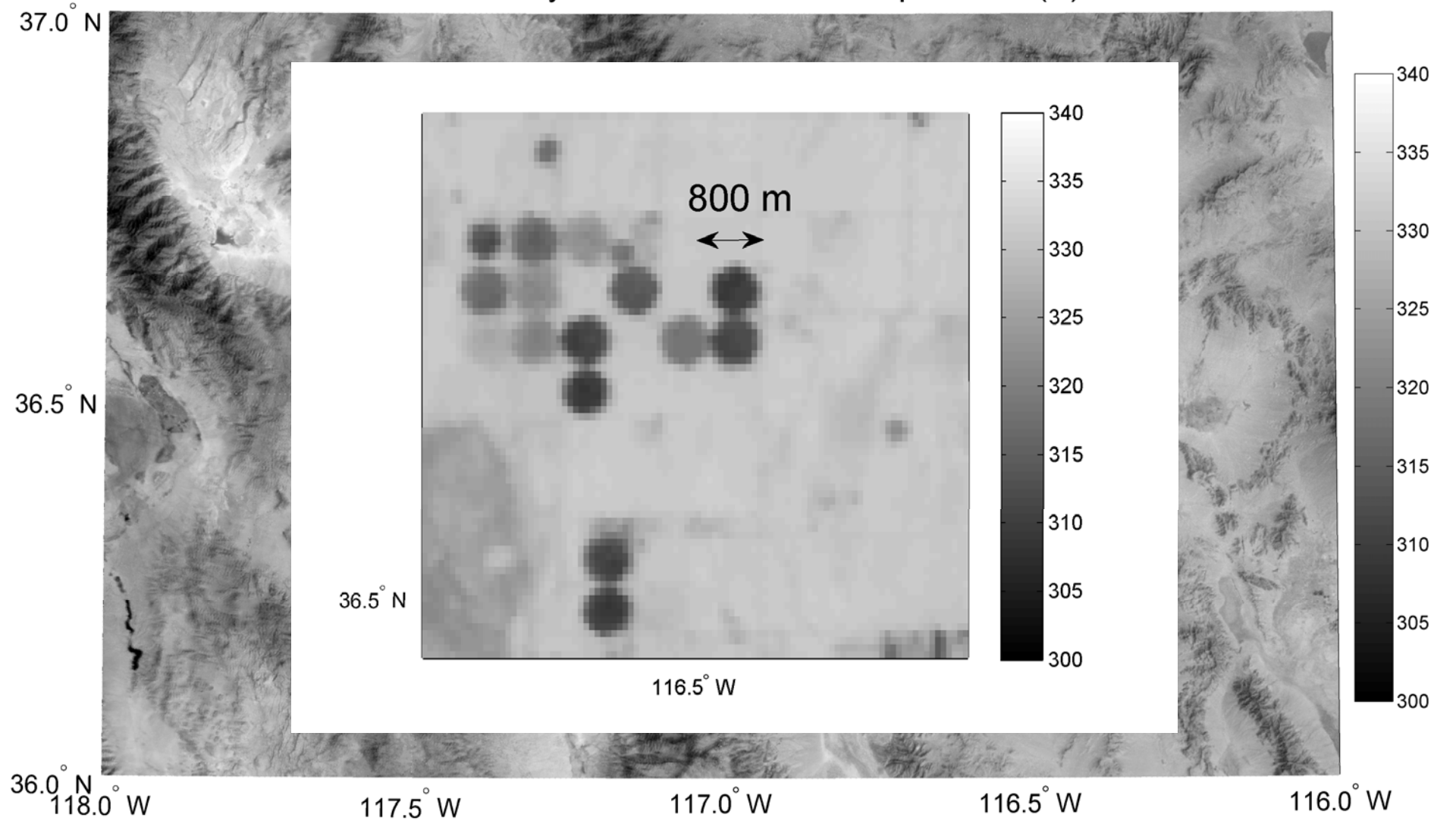


ASTER Mean Summer Normalized Difference Vegetation Index (NDVI)

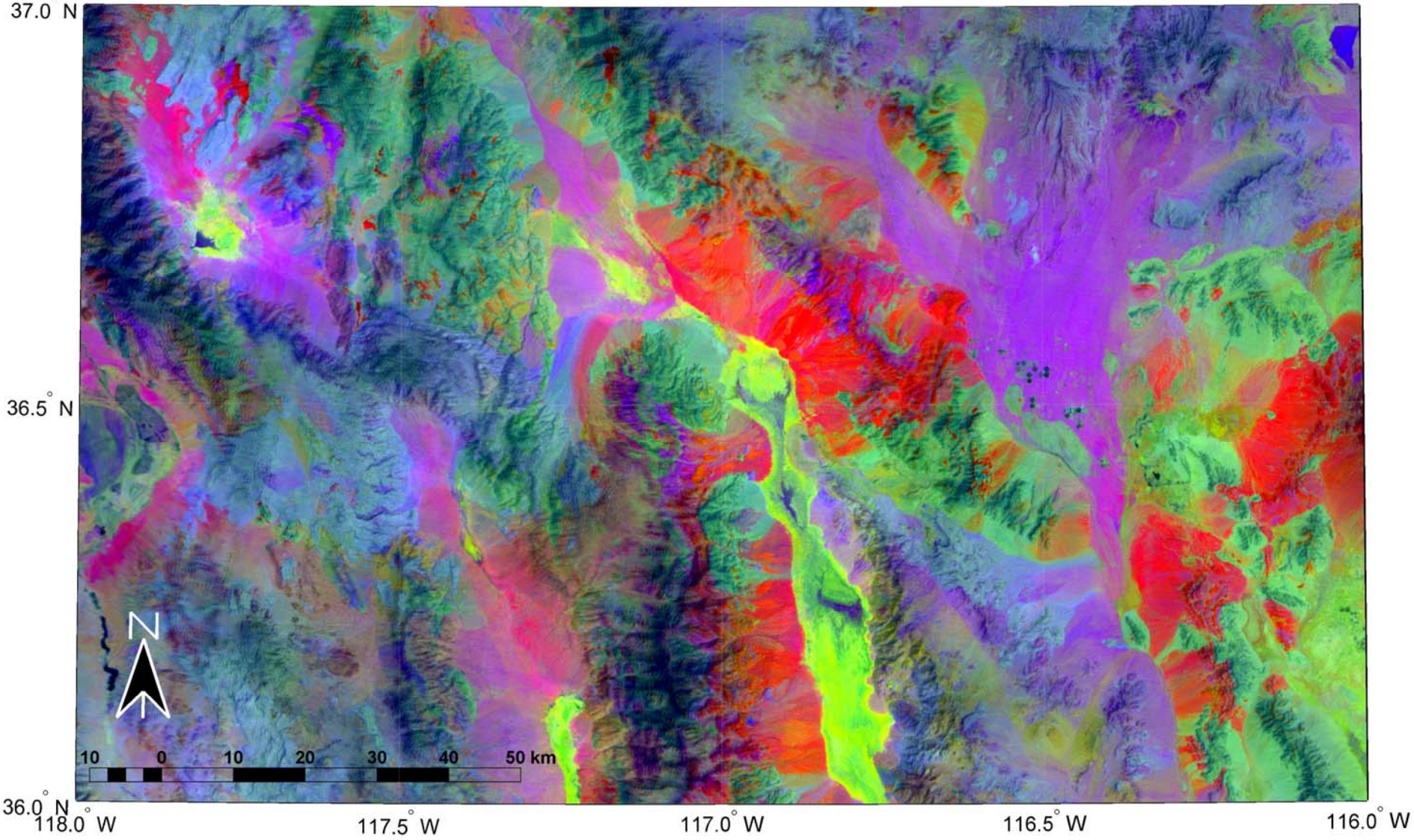



Death Valley
42.5° N
40.0° N
37.5° N
35.0° N
32.5° N
125.0° W
122.5° W
120.0° W
117.5° W
115.0° W
112.5° W
0.8
0.85
0.9
0.95
1


Death Valley - Mean Summer Emissivity - Band 10 (8.3μm)
37.0° N
36.5° N
36.0° N
118.0° W
117.5° W
117.0° W
116.5° W
116.0° W
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8


Death Valley - Mean Summer Temperature (K)
37.0° N
36.5° N
36.0° N
118.0° W
117.5° W
117.0° W
116.5° W
116.0° W
800 m
36.5° N
116.5° W
340
335
330
325
320
315
310
305
300

Death Valley - Decorrelation Stretch - RGB (Band 14,12,10)

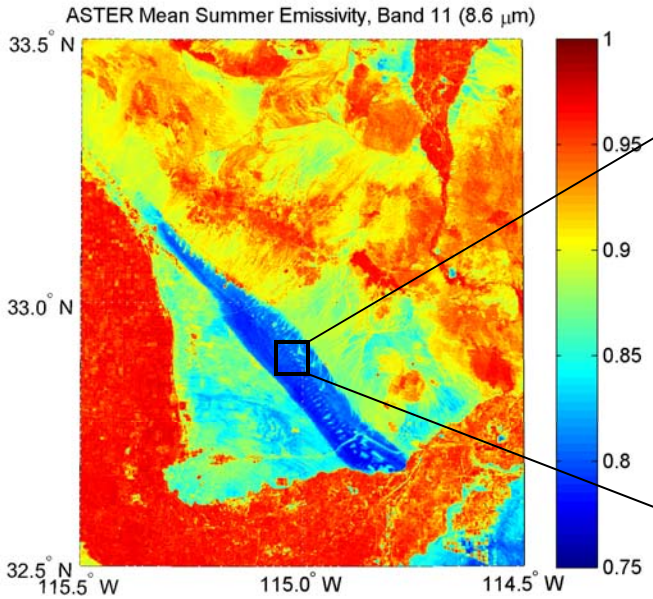


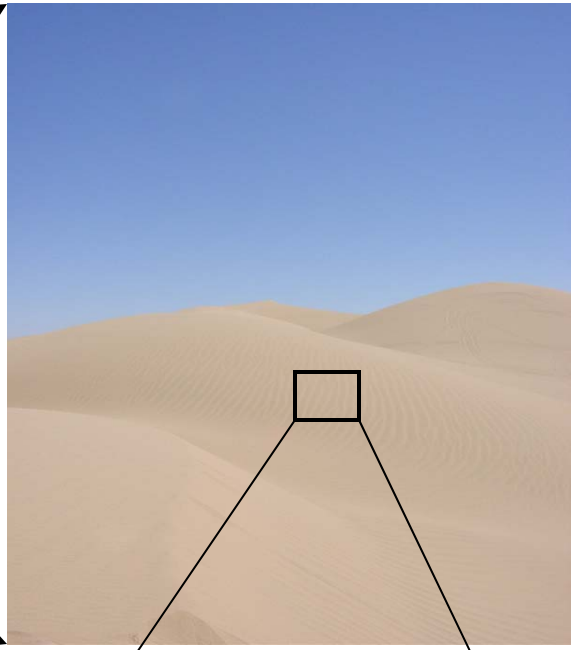
NAALSED Validation

- High spatial resolution (100m) makes validation possible
- Homogenous areas with known composition and small temporal changes
- Sand-dune validation sites:
  - Algodones dunes (Quartz), El Centro, California
  - White Sands National Monument (Gypsum), New Mexico
  - Stovepipe Wells Dunes, Death Valley, California
  - Kelso Dunes, Mojave Desert, California
  - Great Sands National Park, Colorado
  - Sand Hollow State Park, Utah
  - Coral Pink Sand Dunes, Utah
  - Little Sahara, Utah
  - Killpecker Dunes, Wyoming
  - Moses Lake (Basalt), Washington
- Samples measured at JPL using Nicolet Fourier Transform Infrared Spectrometer (FTIR)
- Reflectance converted to emissivity and convolved to ASTER bands

Algodones Dunes, El Centro, California

- 24 March, 2008
- 720 km²
- Little or no vegetation, quartz-rich

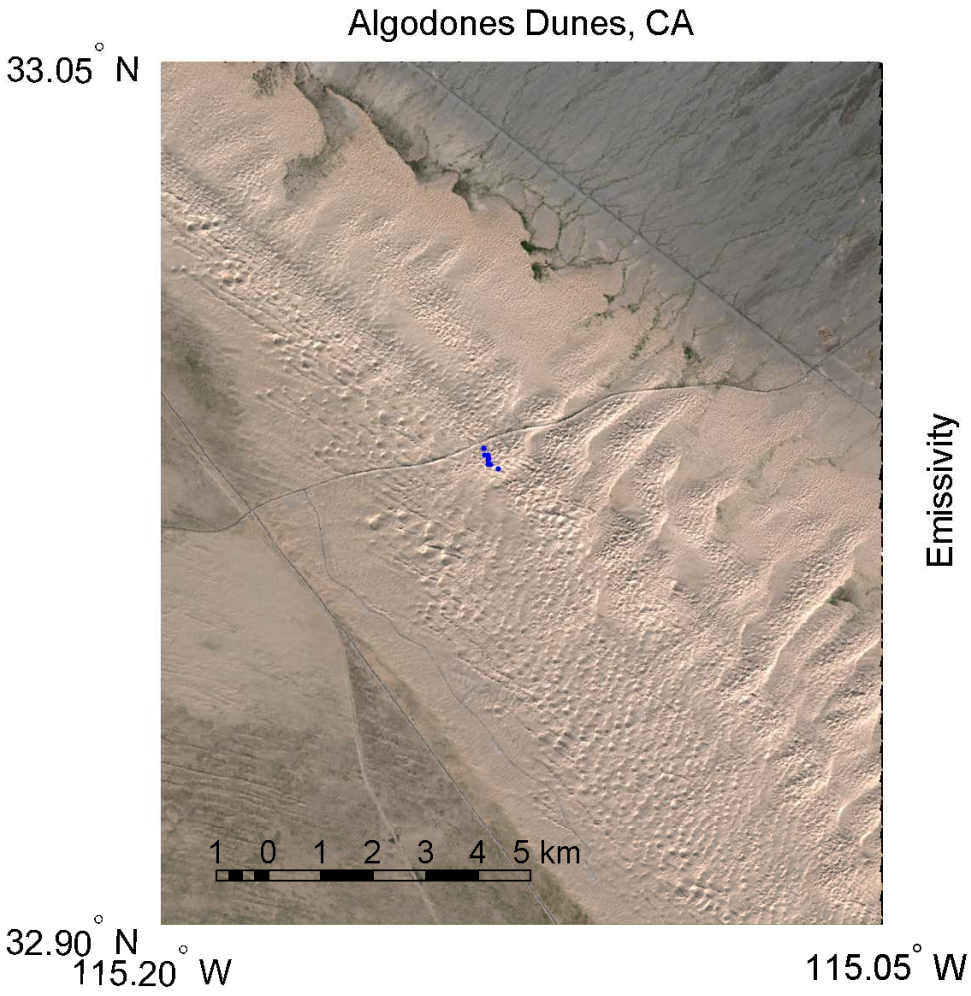


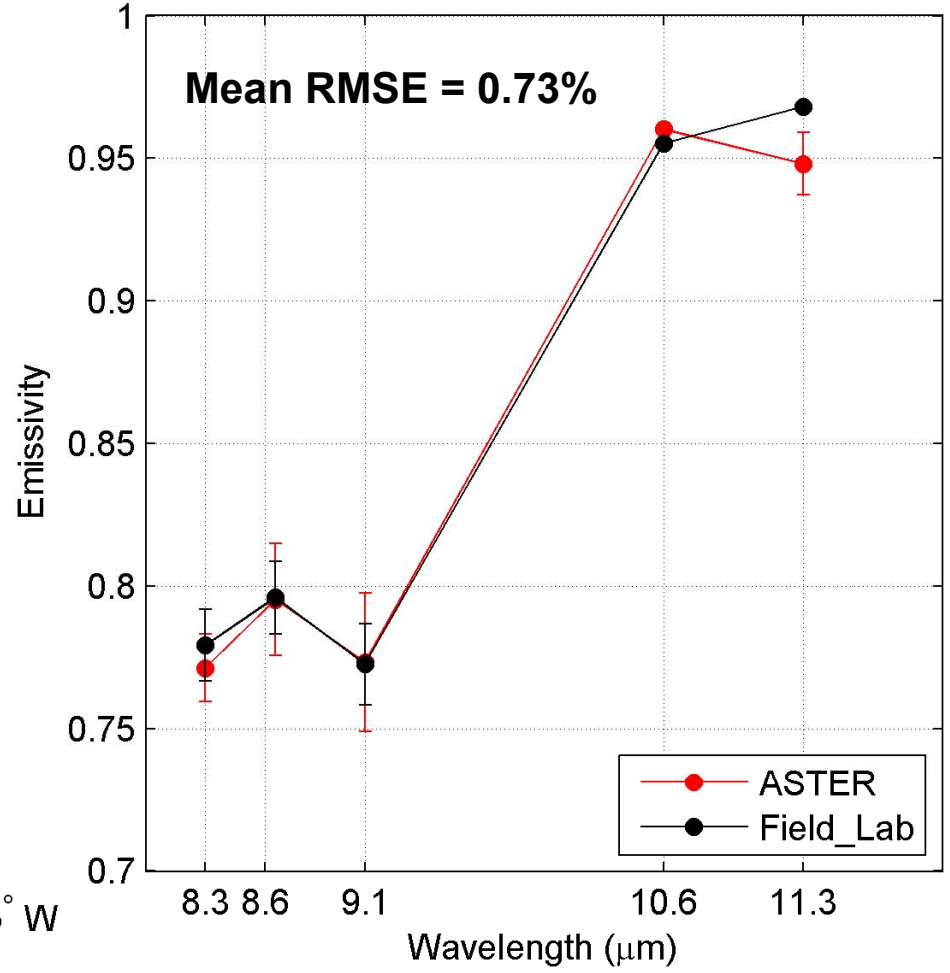


* Alice Baldridge

* Glynn Hulley

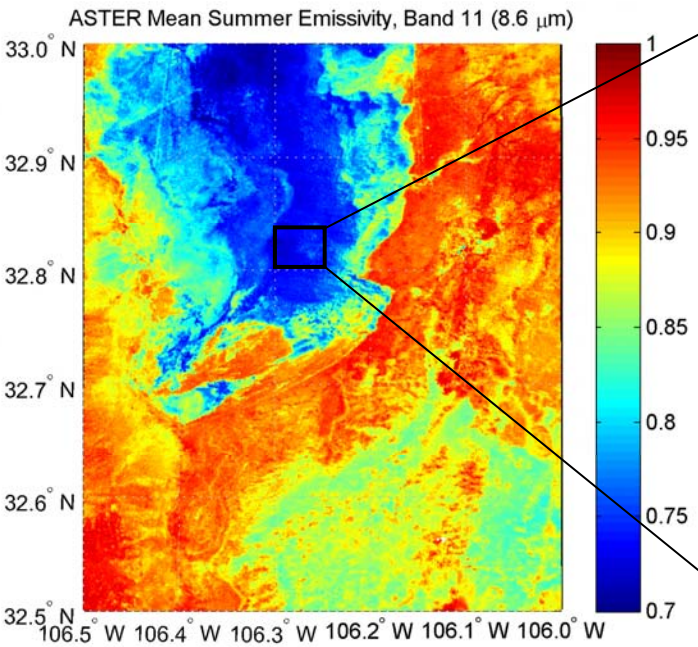
Algodones Dunes, El Centro, California

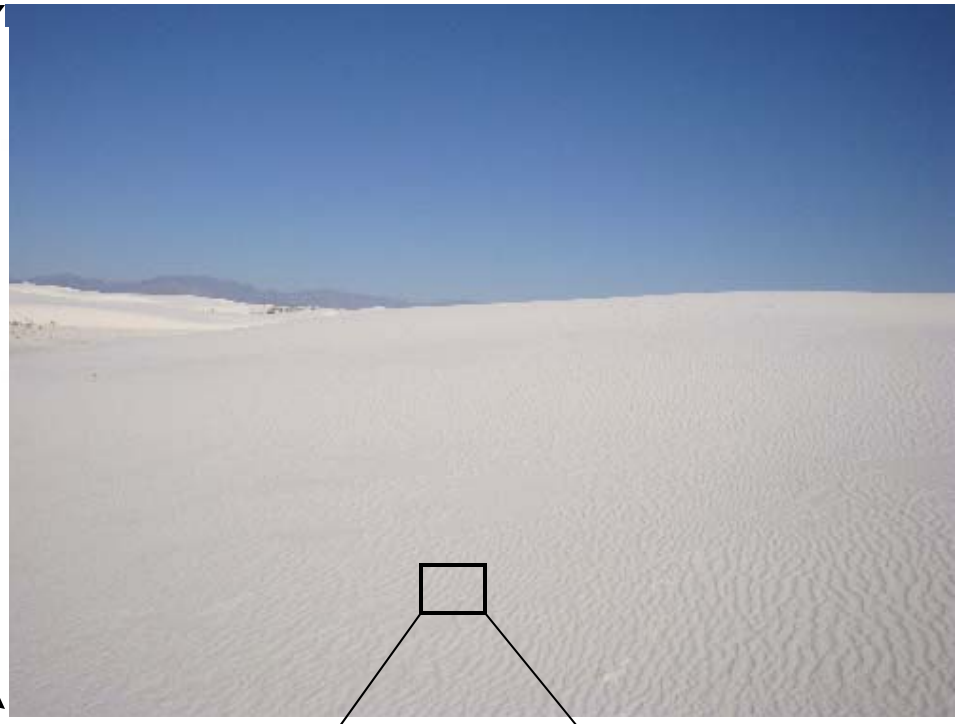




White Sands National Monument, New Mexico

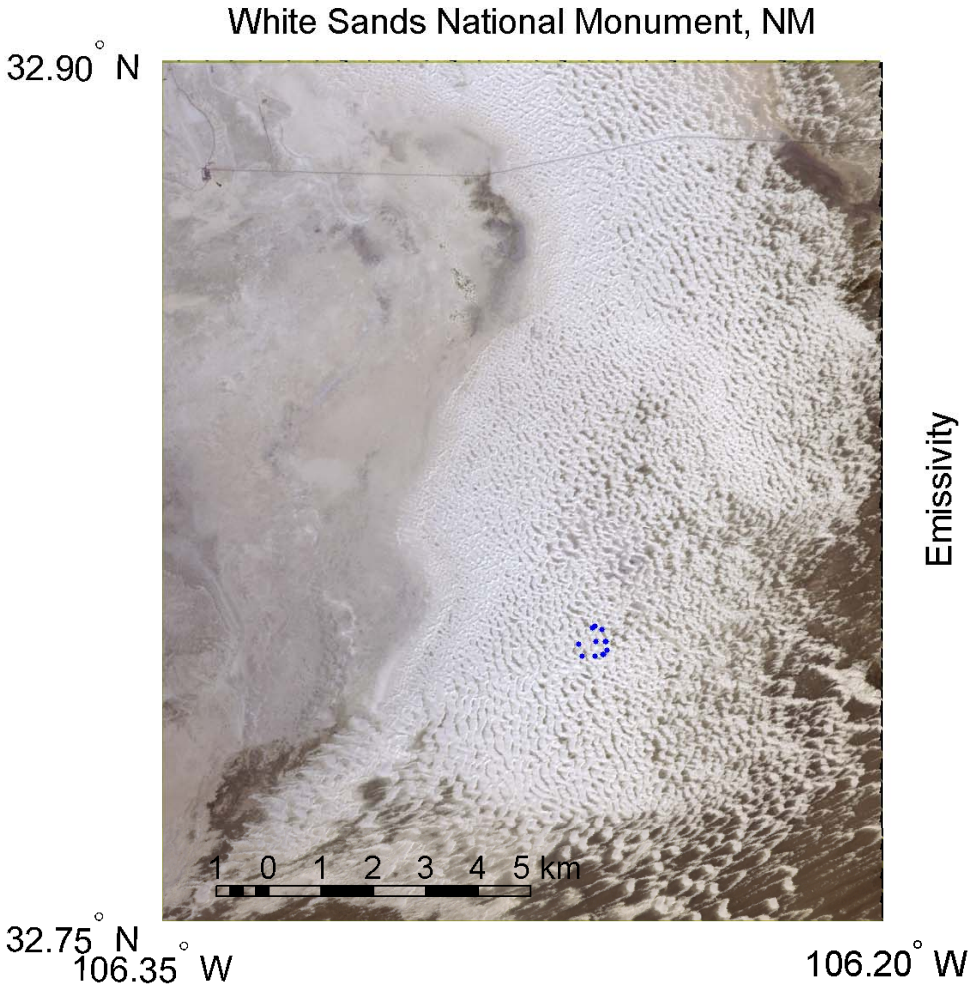
- 20 May, 2008
- 704 km²
- Largest gypsum dune-field in the world

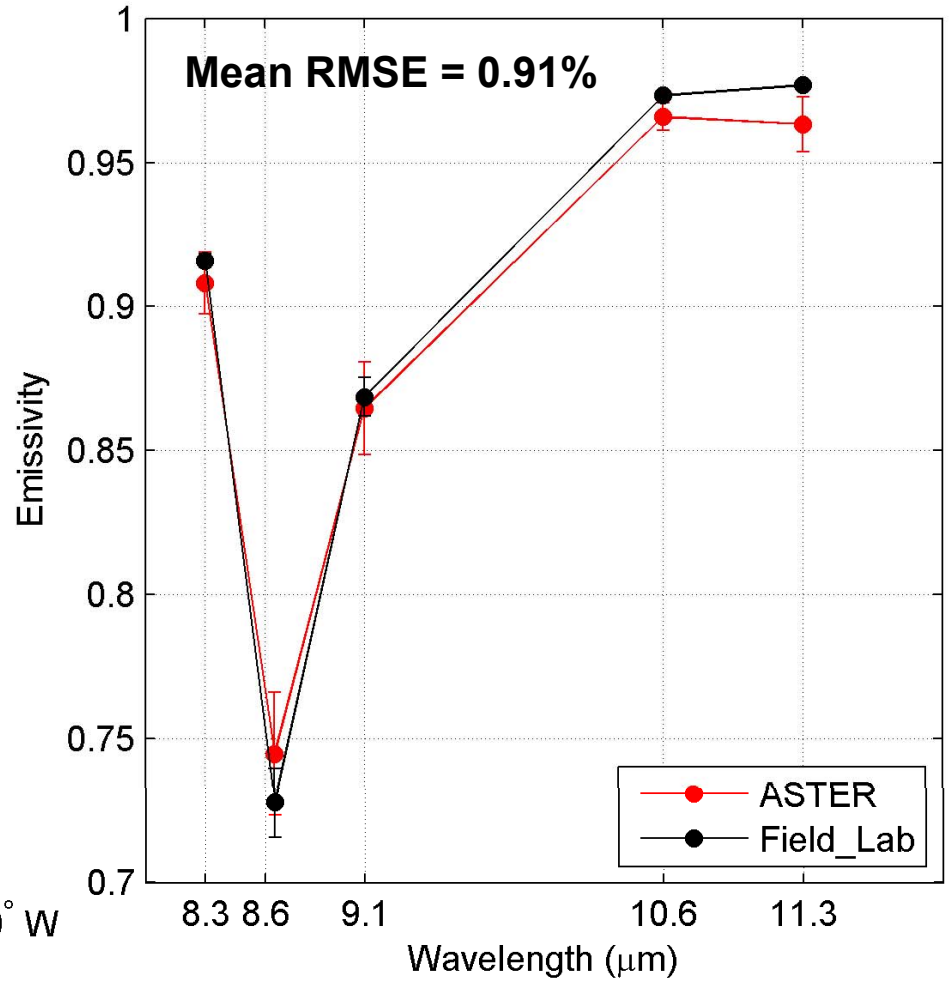




* Glynn Hulley

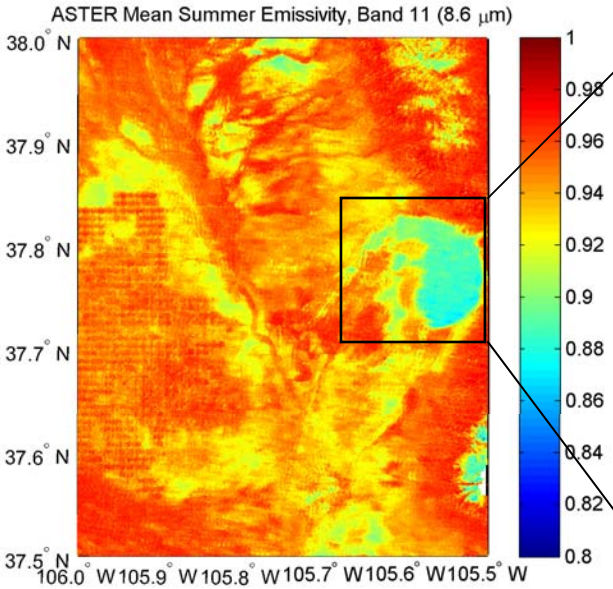
White Sands National Monument, New Mexico

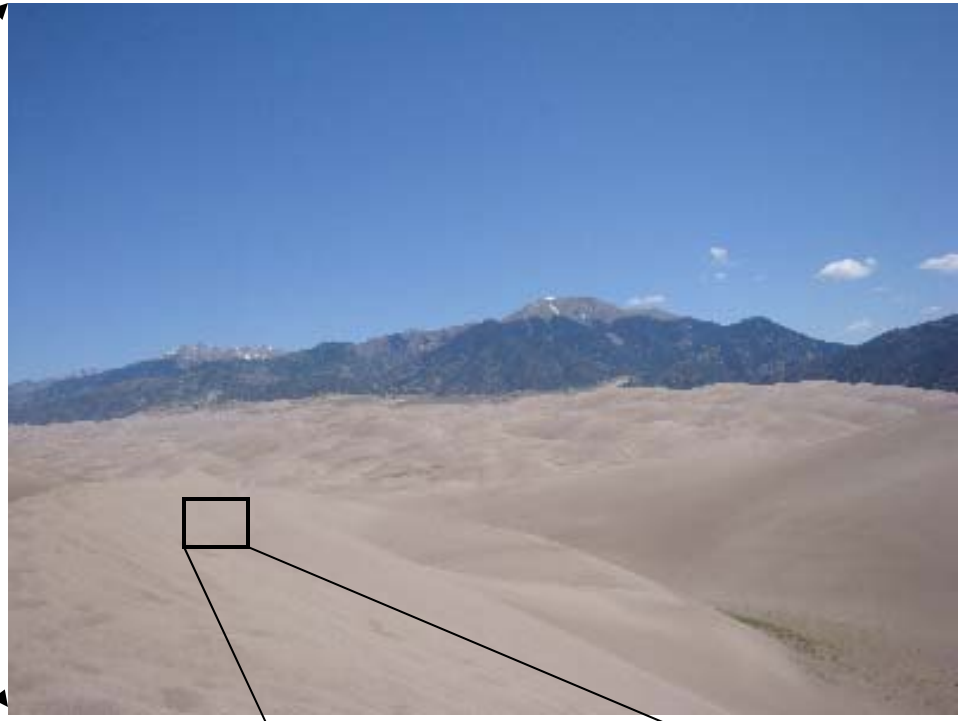




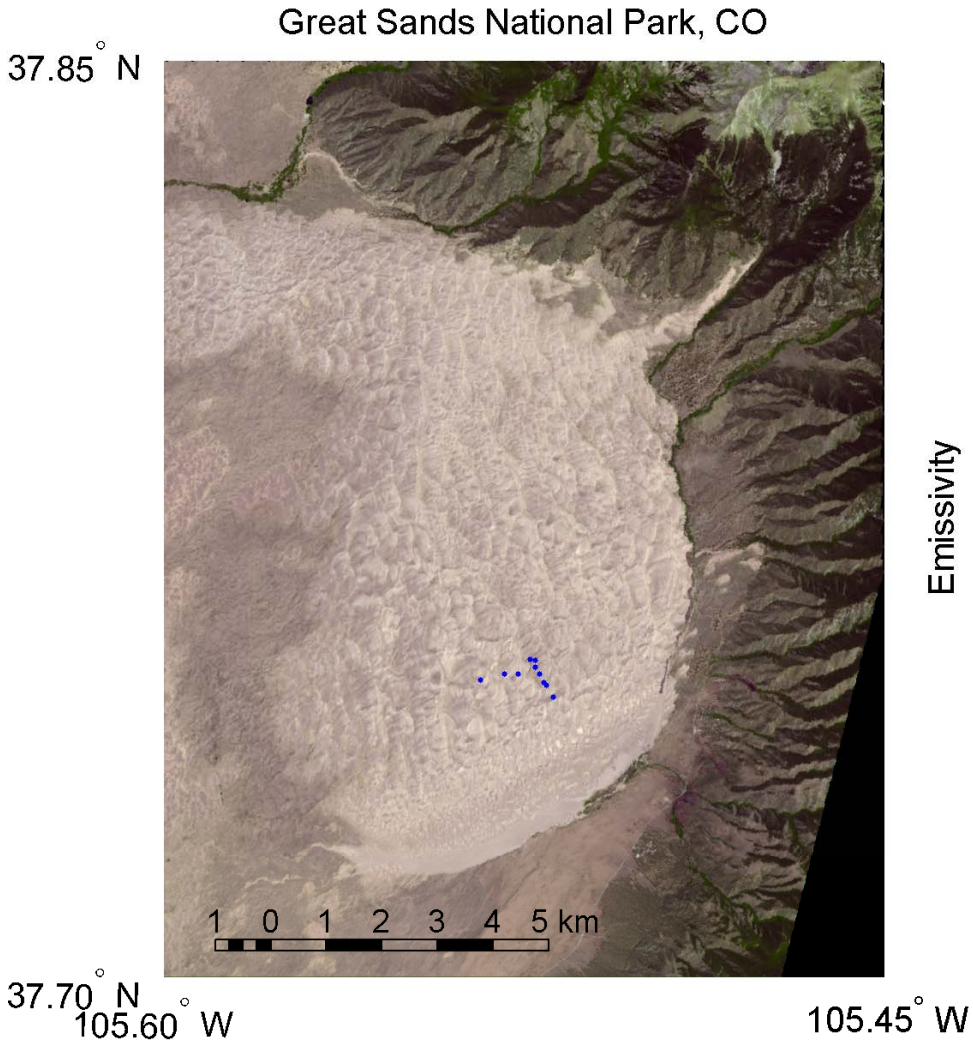
Great Sand Dunes National Park, Colorado

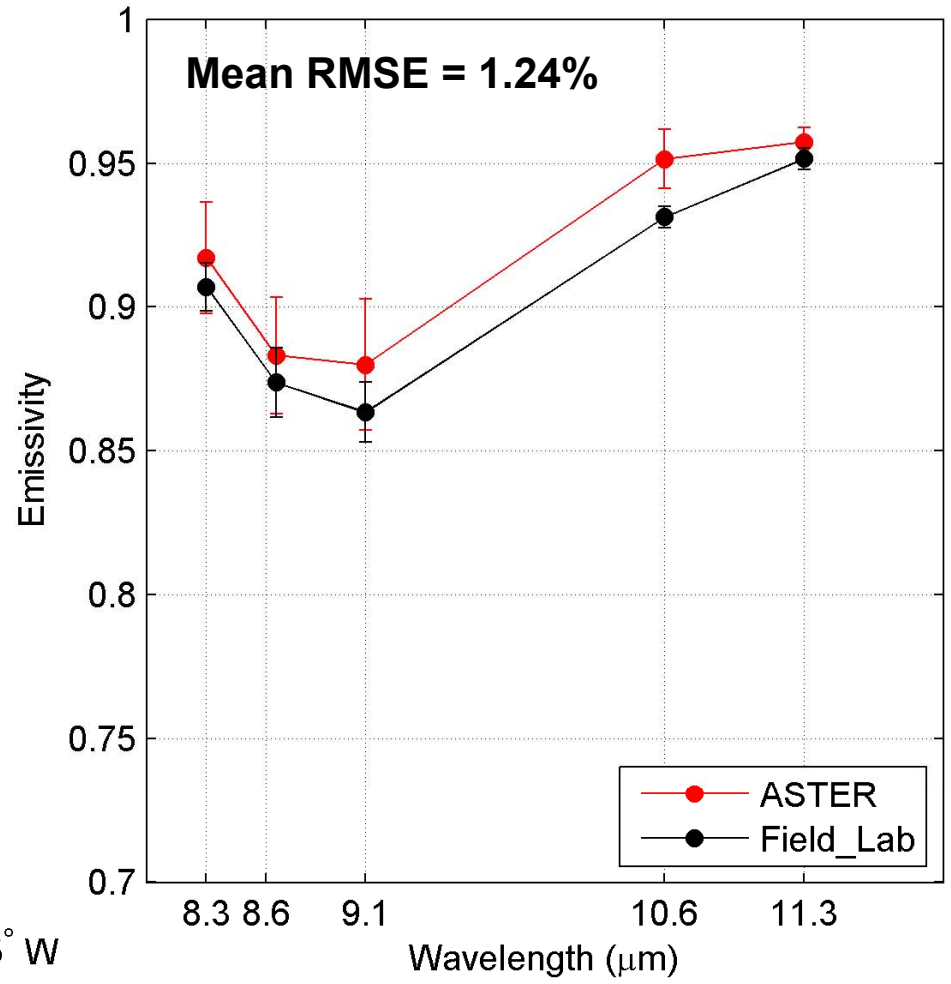
- 24 June, 2008
- 77 km²
- Tallest sand dunes in the USA (750 feet!)





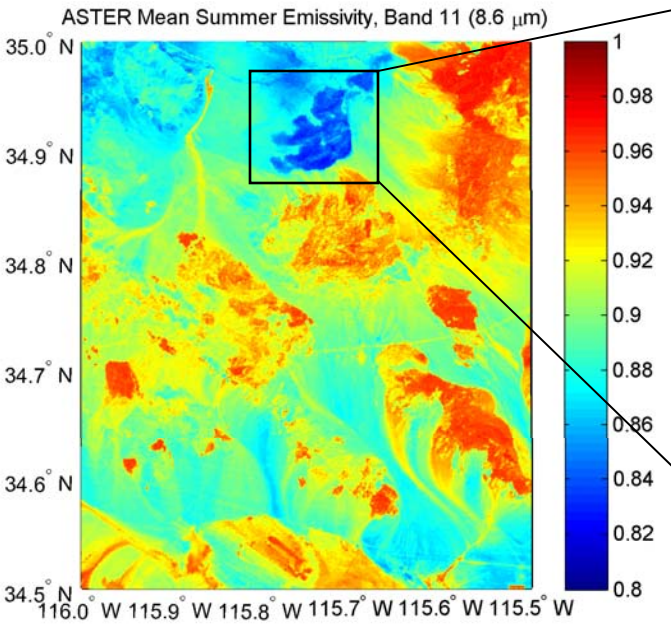
Great Sand Dunes National Park, Colorado

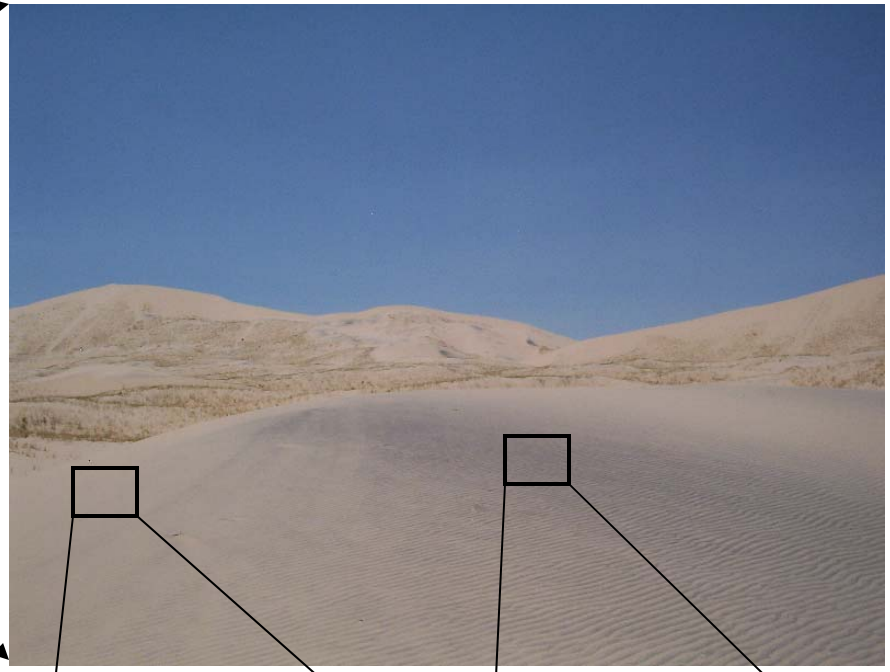




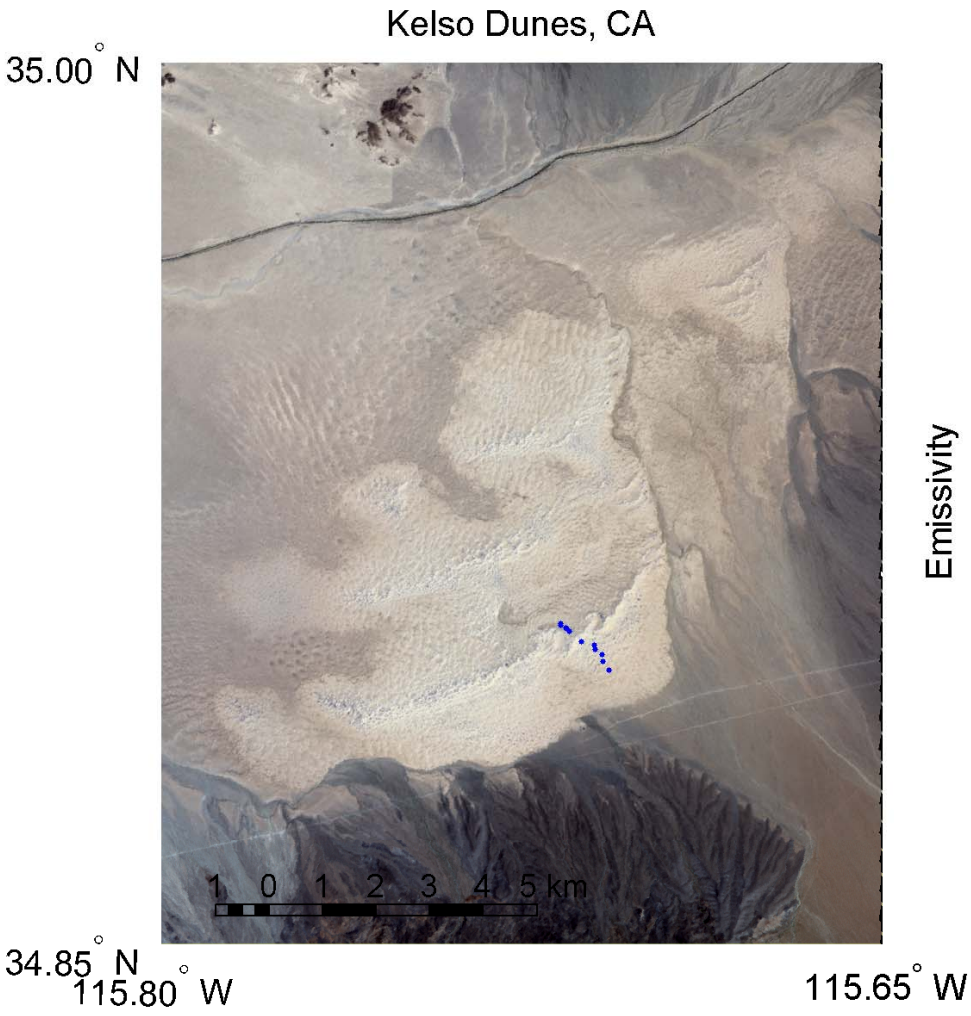
Kelso Dunes, Mojave Desert, California

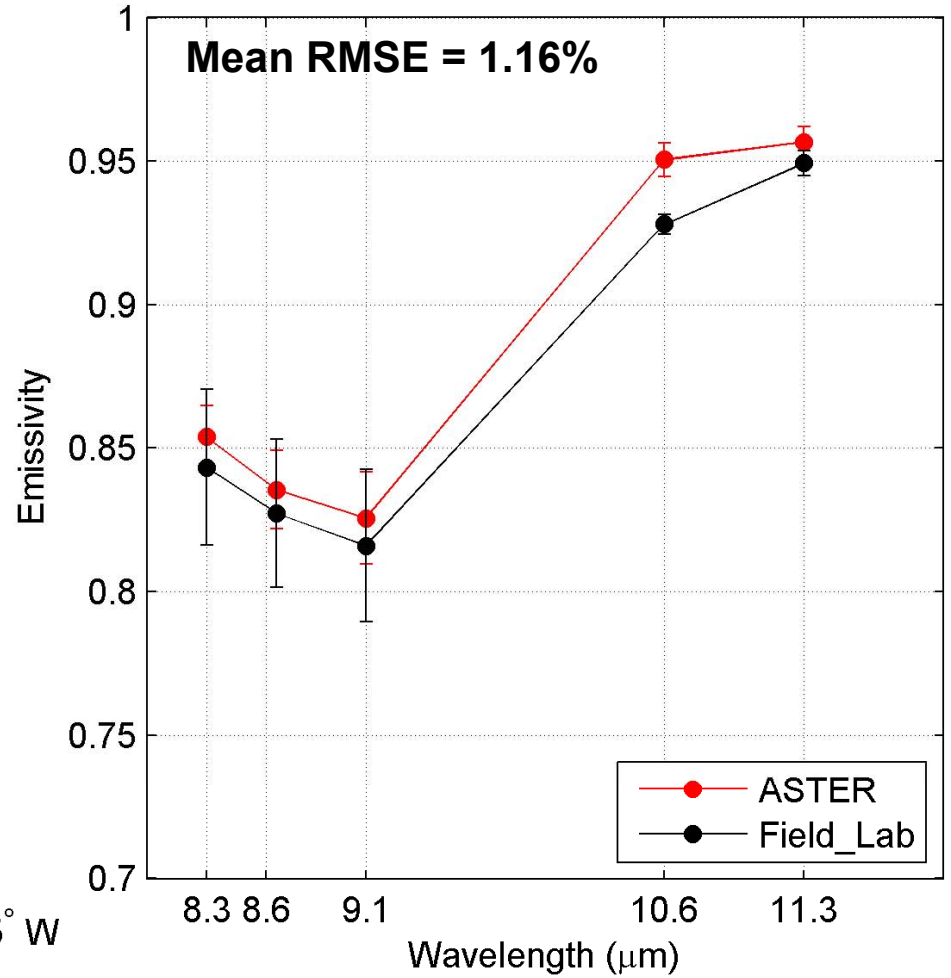
- 11 June, 2008
- 115 km²
- ‘Booming’ dunes



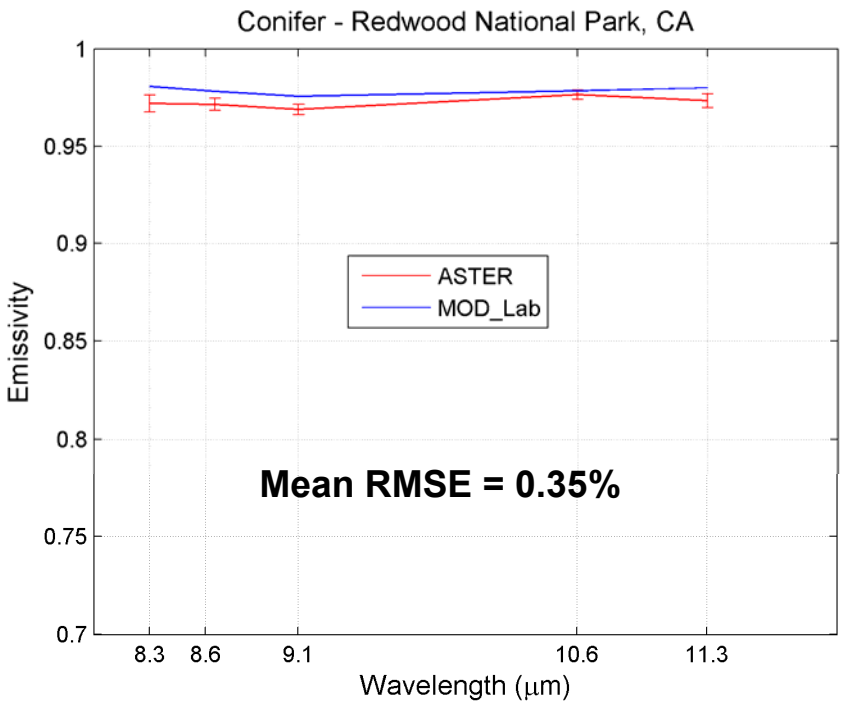


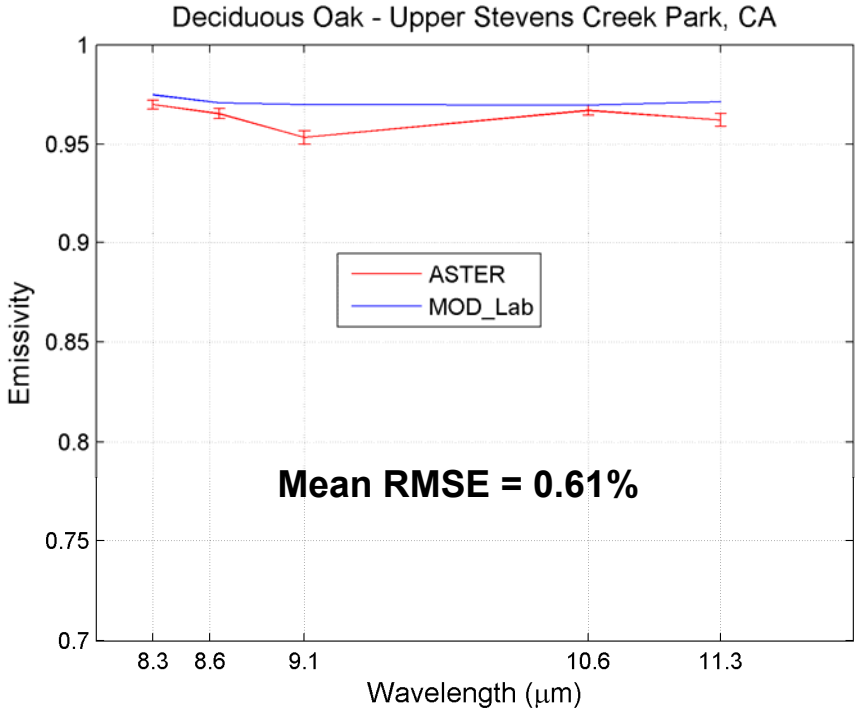
Kelso Dunes, Mojave Desert, California



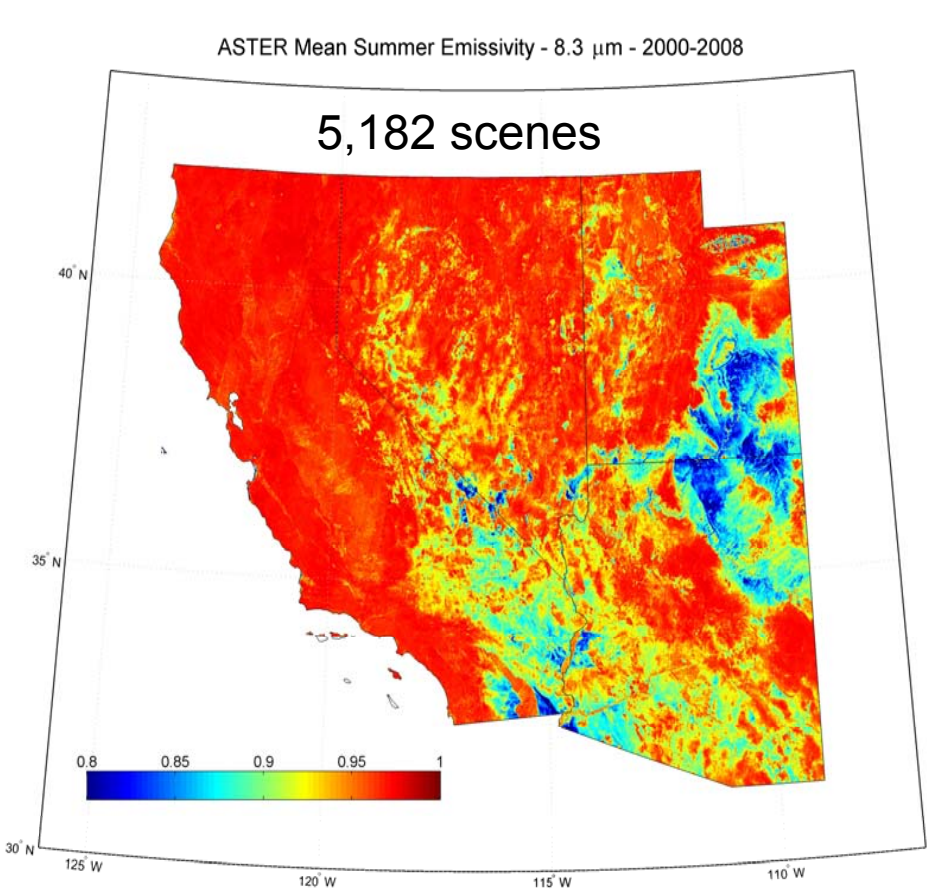


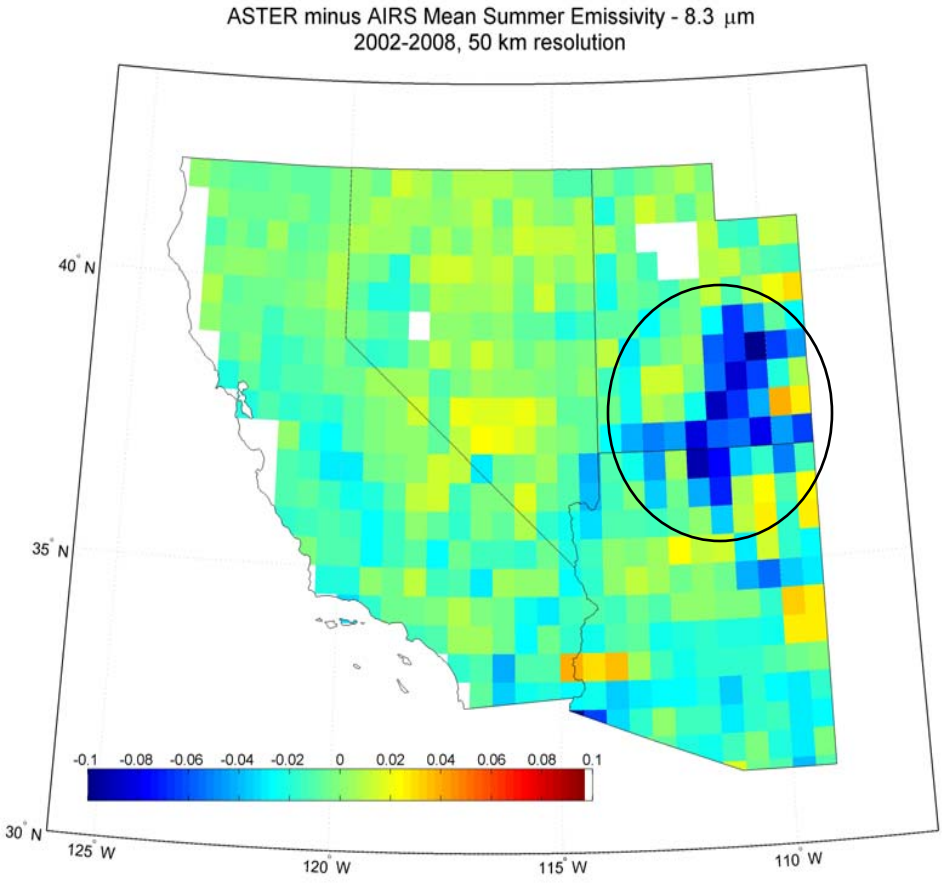
Vegetation – Conifer and Deciduous





ASTER Comparisons with the Atmospheric Infrared Sounder (AIRS)



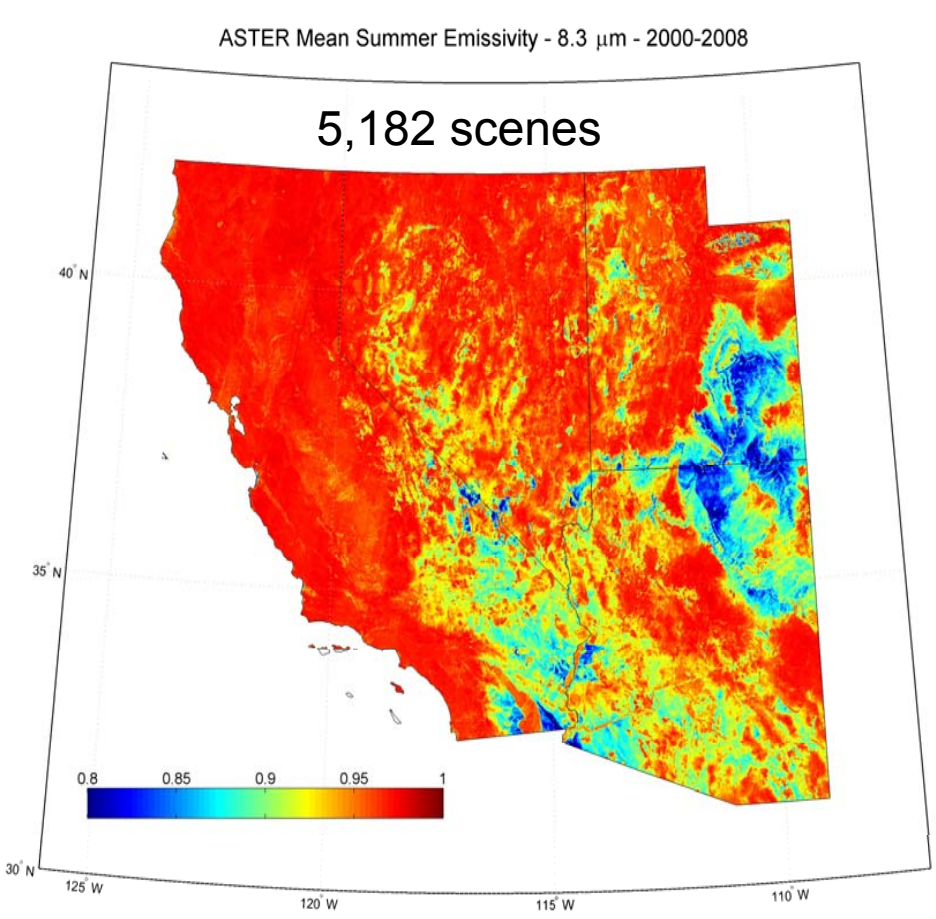


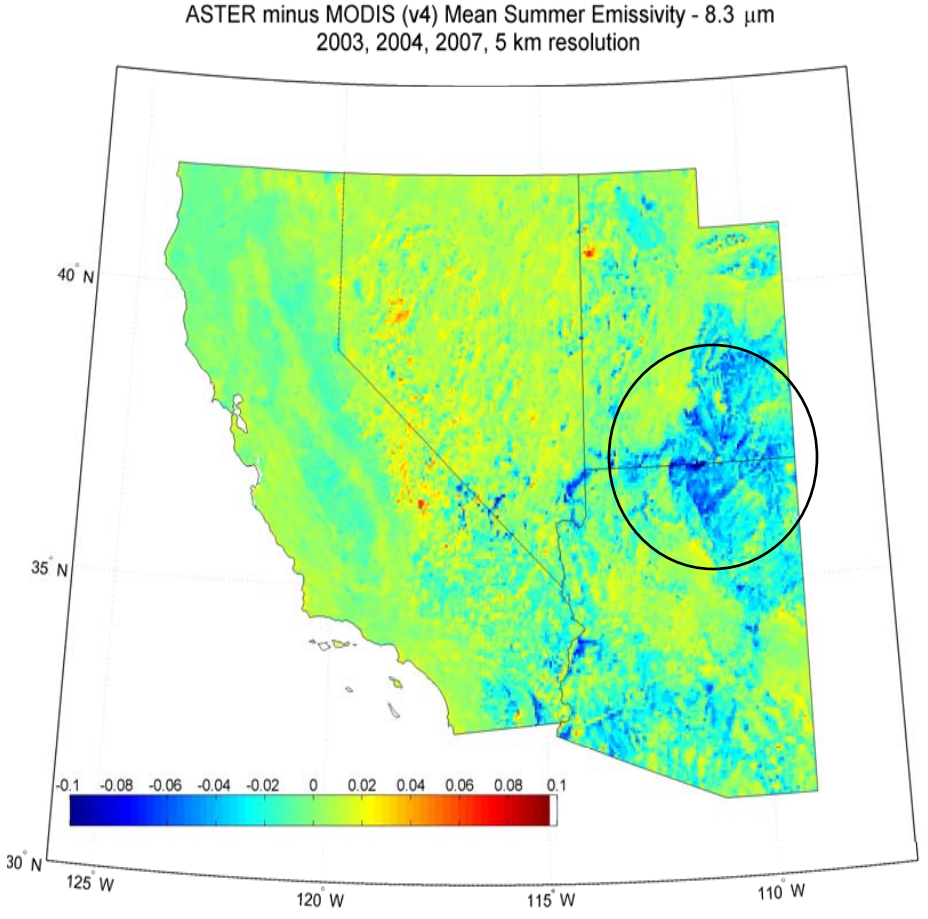
** 80% of pixels have less than 1.5% emissivity difference (~1 K)

** Low emissivity areas have differences up to 7% (6.5 K)

But could be due to AIRS overestimating nighttime emissivities over barren areas

ASTER Comparisons with MODIS (V4)





** 80% of pixels have less than 1% emissivity difference (~0.8 K)

** Low emissivity areas have differences up to 6% (~4.5 K)

Potential Improvements

- Ordering more than one product at a time
- Processing all data (AST_05/08) for given area (eg. Australia) and writing to external drives for shipping
- New WIST system does not give order ID's in email notification title, which makes it harder to keep track of very large orders (500+ scenes) when receiving data notifications (CM SHARED)
- Possibly extending FTP expiration from 5 to 7 days for large orders?

Future Work

- Complete North American ASTER LSTE database by Sep. 2008
- Make data available via FTP at JPL
- Compare ASTER database with new MODIS V5, and AIRS V5 Land Surface Products
- Present at Joint NASA/NOAA Atmospheric Sounding Science Team Meeting, October 2008
- Decide on next area:
  - North Africa?
  - Australia?
  - Northern Eurasia?